

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Environmental & Water
Resources

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TOXICOLOGICAL EVALUATION OF REALISTIC EMISSIONS OF SOURCE AEROSOLS (TERESA): APPLICATION TO COAL-FIRED POWER PLANT-DERIVED PM_{2.5}

CONTACTS

Thomas J. Feeley III

Technology Manager
Environmental & Water Resources
412-386-6134
thomas.feeley@netl.doe.gov

William Aljoe

Project Manager
412-386-6569
wiliam.aljoe@netl.doe.gov

PARTNERS

Electric Power Research Institute

Palo Alto, CA

Harvard University School of Public Health

Boston, MA



Description

Objective

The primary objective of the Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA) program is to investigate and clarify the impact of the sources and components of fine particulate matter (PM_{2.5}) on human health via a set of realistic animal exposure experiments. Secondary objectives of the study include: (1) evaluation of the relative toxicity of coal combustion emissions and mobile source emissions, their secondary products, and ambient particles; (2) providing insight into the effects of atmospheric conditions on the formation and toxicity of secondary particles from coal combustion and mobile source emissions; (3) providing information on the impact of coal type and pollution control technologies on emissions toxicity; and (4) providing insight into toxicological mechanisms of PM-induced effects on normal and susceptible subpopulations.

Background

The TERESA program, managed by the Electric Power Research Institute (EPRI) and including the Harvard University School of Public Health (HSPH) as a key participant, was initiated in July 2002 with non-DOE sources of funding. The work is a significant improvement over previous studies to investigate the toxicity of coal combustion-derived particulate matter by virtue of several highly innovative and unique design features. First, all toxicological studies of coal combustion emissions to date have used primary emissions, i.e., coal fly ash. The relevance of primary emissions to human population exposure is unclear, since primary emissions are now very low with the widespread introduction of particulate controls on power plants. It is the secondary particulate matter formed from SO₂ and NO_x in stack emissions as well as any residual primary PM that is of interest. No efforts to consider and account for secondary atmospheric chemistry have been made to date.

Summary

The DOE-EPRI Cooperative Agreement involves the analysis and interpretation of the field data collected at an Upper Midwest plant, followed by the performance and analysis of similar field experiments at two additional coal-fired power plants in the Southeast and Midwestern U.S., utilizing different coal types and with different

COST

Total Project Value

\$1,609,122

DOE/Non-DOE Share

\$771,351 / \$837,771

PERIOD OF PERFORMANCE

September 2003 to
June 2006

ADDRESS

National Energy Technology Laboratory

626 Cochran's Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

539 Duckering Bldg./UAF Campus
P.O. Box 750172
Fairbanks, AK 99775-0172
907-452-2559

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

plant configurations. Emissions are introduced into a reaction chamber within a mobile laboratory to simulate oxidative atmospheric chemistry and both primary and secondary materials are extensively characterized, including NO₂, SO₂, ozone, NH₃, hydrocarbons, particle number and mass, sulfate, nitrate, elemental/organic carbon, ammonium, and metals. Test atmospheres containing realistic concentrations of primary emissions and oxidative products – including oxidized plant emissions and secondary organic aerosols (SOA) from other sources that are often present in real atmospheres – are utilized in two toxicological assessment steps within a separate mobile laboratory. The first step utilizes normal laboratory rats and the second uses rats that have been surgically “compromised” to model the responses of individuals with cardiovascular problems. This last step includes telemetric methods for the assessment of cardiac function.

Accomplishments

- Fieldwork has been completed at the Upper Midwest power plant, which burned sub-bituminous coal. Primary particles extracted from the stack and diluted by the atmospheric simulation system within the mobile laboratory were found to be representative of particles actually being emitted from the stack.
- Three sets of animal exposures were performed at the Upper Midwest plant: (1) oxidized emissions + SOA; (2) oxidized and neutralized emissions + SOA; and (3) oxidized emissions. Toxicological assessments were carried out and no significant differences between exposed and unexposed animals were observed.
- Stack sampling and several initial animal exposures were performed at the Southeast power plant, which burns low-sulfur bituminous coal. Exposure characterization and toxicological data analyses are currently underway.

Planned Activities

- Prepare a topical report and peer-reviewed journal articles for the Upper Midwest power plant findings.
- Complete exposures of normal and compromised rats at the Southeast power plant along with interpretation of the toxicological data.
- Prepare for fieldwork at the third plant, located in the midwest.
- Determine the most appropriate approach for the mobile source emissions component of TERESA.

Issues

Pilot-scale combustors, which were used in many previous toxicological studies of coal plant emissions, may not accurately mimic actual stack emissions due to differences in surface to volume ratios and thus time-temperature histories. Some

studies have also collected coal fly ash from power plant electrostatic precipitators (ESPs) and used this collected material in intra-tracheal instillation or *in vitro* studies. Neither of these modes of delivery of PM is optimal due to the likelihood of extremely high tissue doses and non-representativeness of the particles.

